

Current activities of the Cracow LOFAR group



The Krakow LOFAR group

- **MKSP and SKSP**
- **2 full KSP and 6 associated KSP members**
- **4 scientific projects: 2 from LC0, 2 from LC1**
- **Current activities:**
 - **The POLFAR project**
 - **Introducing LOFAR software to local computers**
 - **LC0 projects: SQ & NGC 6946**
 - **LC1 projects: NGC 4449 & 4490**
 - **MSSS NG survey**



POLFAR

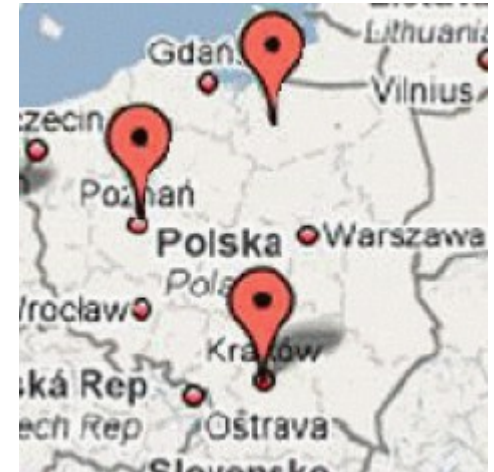
Bałdy - 20 km from Olsztyn, University of Warmia and Mazury

Borówiec near Poznań, Space Research Center of Polish Academy of Sciences. Astrogeodynamic Observatory.

Łazy - 20 km from Kraków, near Bochnia, Jagiellonian University

PIONIER - Polish Optical Internet provider
a nationwide broadband optical network for e-science

Polish state officials have signed the contract few days ago – we are nearly at the end!



Computing power

- LOFAR software installed on 3 nodes of the old cluster in our Observatory, 2XQUAD CORE E5420 XEON 2,5GHz, HDD 2-3TB. Installed from scratch under Ubuntu 12.04 LTS on one node, disk image copied to other nodes by Clonezilla.
- Two additional machines are on the way – they have lower amount of RAM, but are equipped with Quad Cores and have over 2 TB of disk capacity
- Tests of the new version of the software – will be installed on the other nodes

Great help from Andreas Horneffer

- 30% slower than CEP1
- Despite lower speed, they offer a fair chance to test strategies, do flagging, simulate the A-Teams...
- NGC 4449 project – first to be fully processed in Kraków





More computing power?

The Polish Grid Infrastructure has been built within the **PL-Grid** project to provide the Polish scientific community with an IT platform based on computer clusters, enabling research in various domains of e-Science.



<http://www.plgrid.pl/en>

Cyfronet in Krakow – part of PL-Grid

LOFAR team: Andrzej Oziębło, Maciej Czuchry, Patryk Lason, Tomasz Szczepieniec, with great help from Stefan Froehlich, Bochum

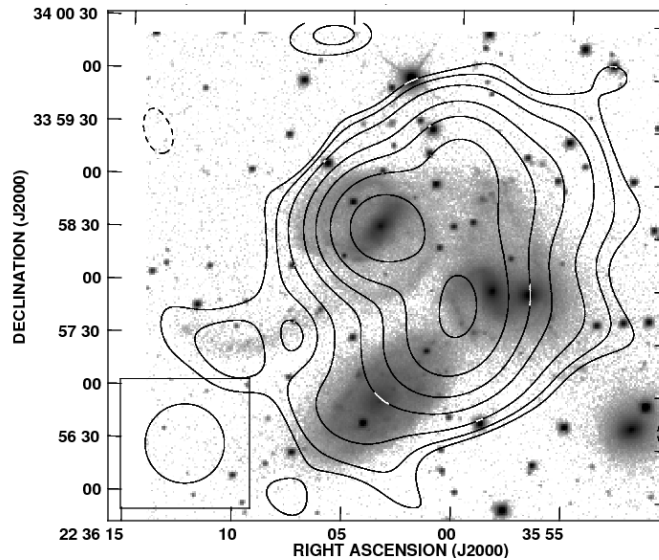
- **LOFAR software on one node**
- **Calibration test ended with success!**
- **Several times faster than in our Observatory**
- **Now: joint attempts to develop JUROPA-like procedures (scripts from Bjoern Adebahr) to make ZEUS basic POLFAR computing facility**

News on PROJECTS

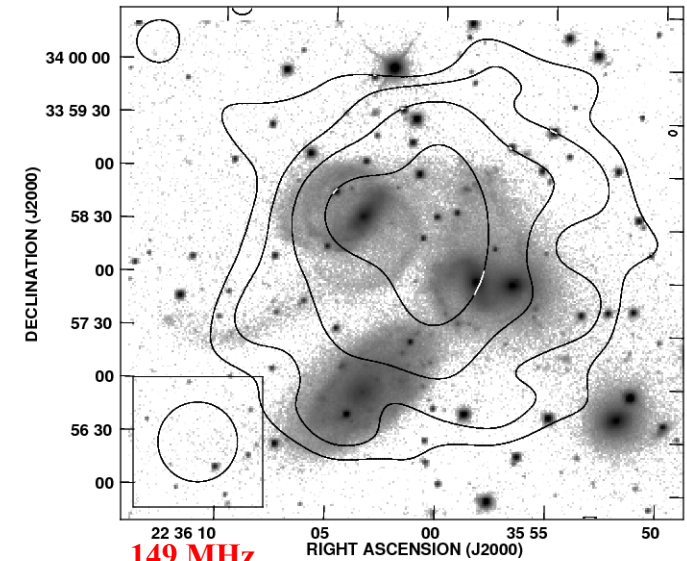


Observations of the SQ

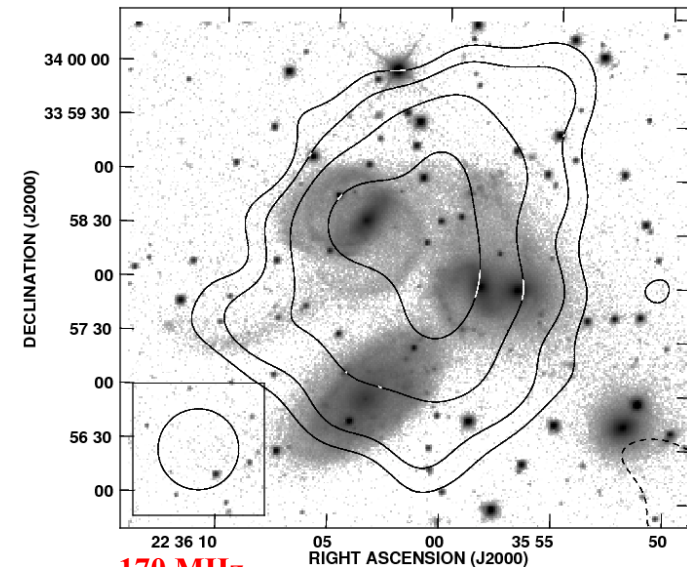
LOFAR Survey of Nearby Galaxies – LOFAR Cycle 0



1420 MHz



149 MHz

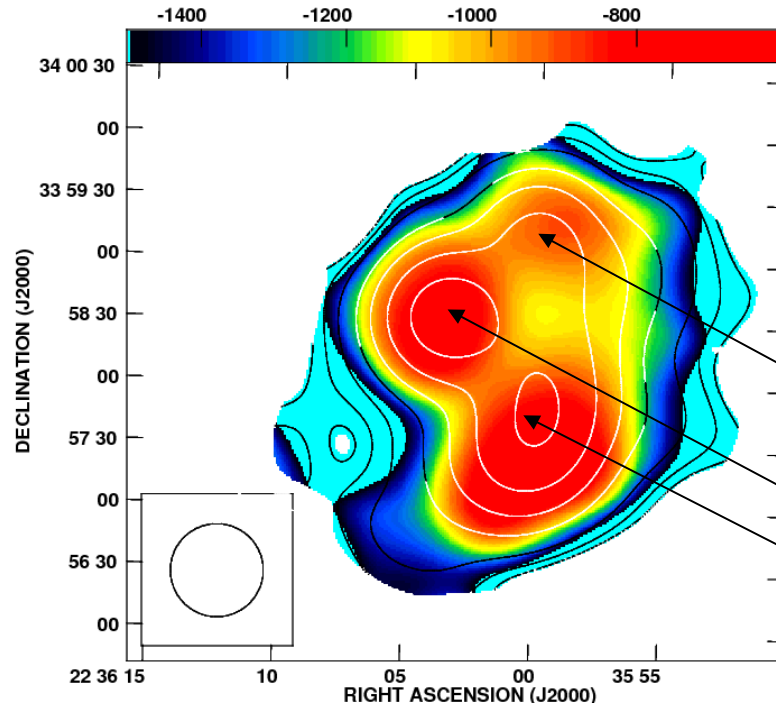


170 MHz

- Preliminary results
- Two LOFAR maps, convolved to a common beam of 45 arcsec (to be compared with the VLA 20cm data)
- LOFAR maps – preliminaries (the second one is nearly untouched!)
- VLA map – fully exploited

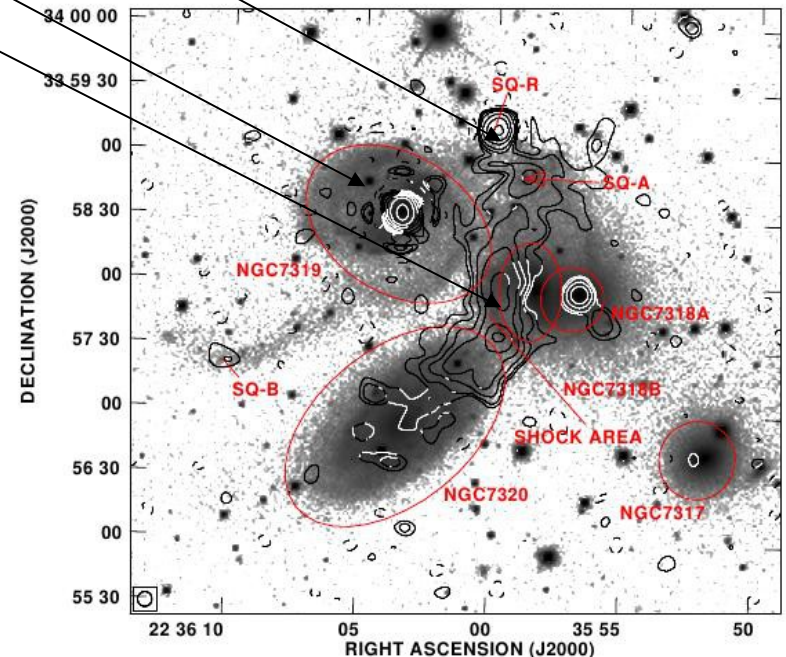
Observations of the SQ

LOFAR Survey of Nearby Galaxies – LOFAR Cycle 0



- **Spectral index map is limited by the size of the envelope at 1425 MHz**
- **Still, different entities are easily visible**
- **And the map is quite similar to that at the higher**

- **Preliminary estimate for the magnetic field in the shock area (near the emission maximum):**
 $10.0 \pm 1.5 \mu\text{G}$
- **MF+CR energy density: $\sim 10^{-11} \text{ erg cm}^{-3}$**
- **Similar to the value derived at the higher frequencies, and still**





Observations of the SQ

LOFAR Survey of Nearby Galaxies – LOFAR Cycle 0

To sum up:

- **Promising results**
- **There is still some work to be done**
- **Main goal: achieving at least 25 arcseconds resolution (hoping to get 15!)**

Project News:

- **It turned out that the A-Team flagging failed due to the broken tiles issue**
- **The best package is now being re-processed**
- **Extensive flagging of bad baselines/antennas to ensure good results**
- **NGC 7331 is detected in the field!**
- **The odd shape of the strong sources is due to their morphology – not beam problem**

Scientific plans:

- **Study of the shock**
- **Hunt for the TDG**
- **Is there a continuum counterpart for the neutral gas tail?**
- **Can we get the polarisation?**
- **Analysis conducted together with our WSRT 22cm and VLA 6cm data**

Observations of NGC6946

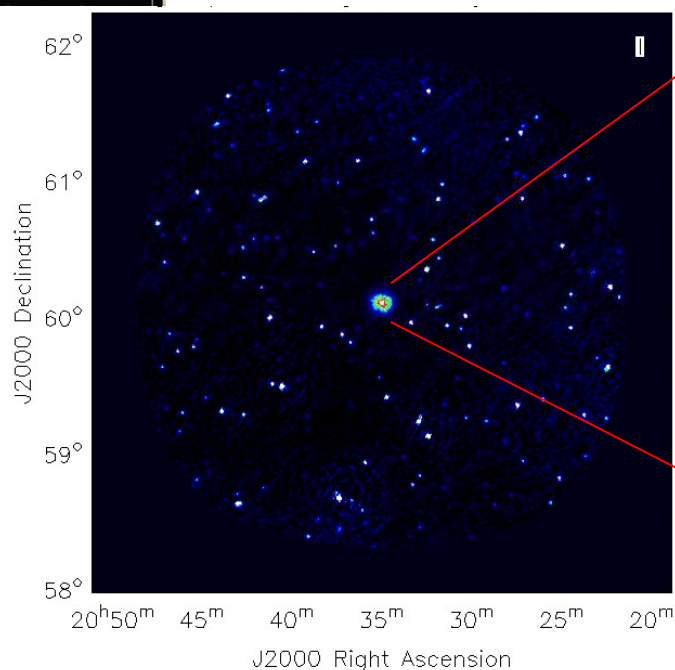
LOFAR Survey of Nearby Galaxies – LOFAR Cycle 0

Preliminary results from Block 0

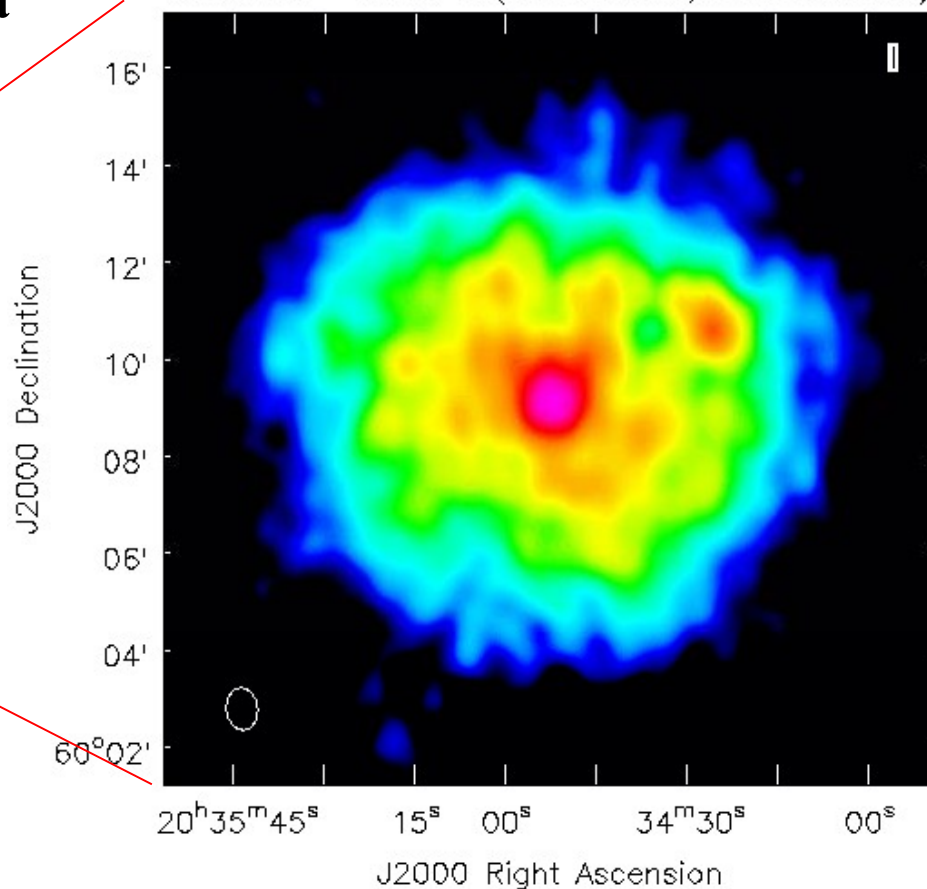
SB000 – SB026

Data uv < 6klambda

Full field of view



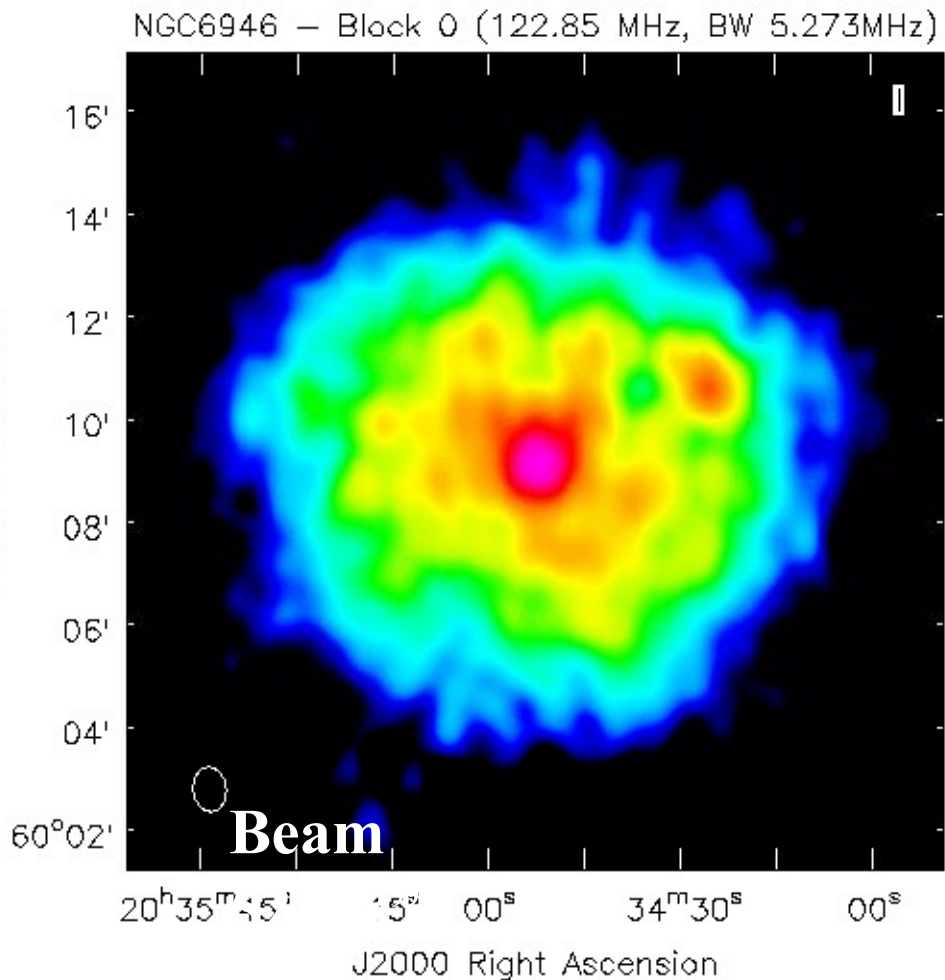
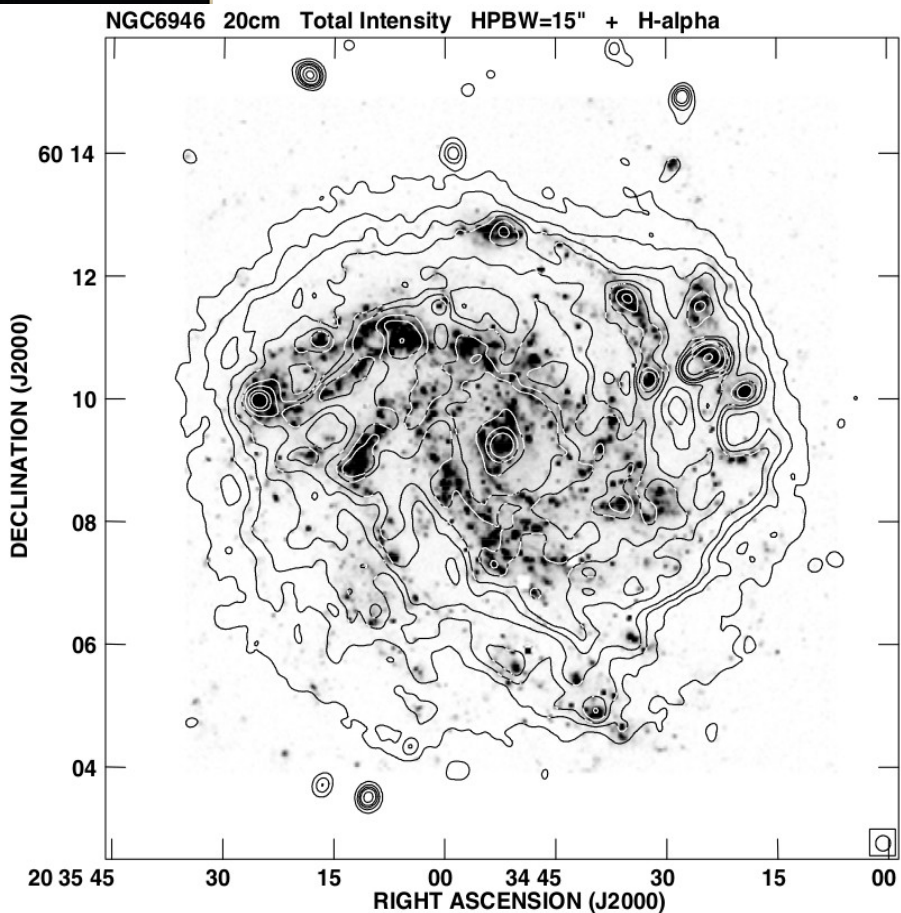
NGC6946 – Block 0 (122.85 MHz, BW 5.273MHz)



Cleaning in awimager

Observations of NGC6946

LOFAR Survey of Nearby Galaxies – LOFAR Cycle 0



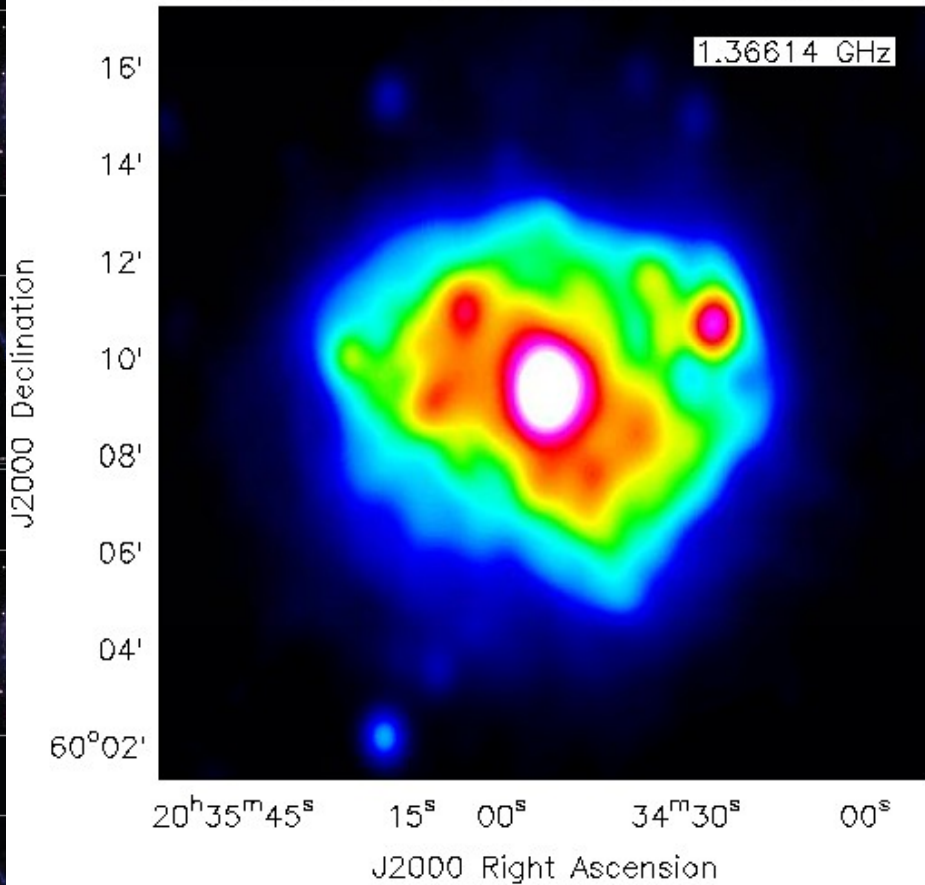
Beck, R A&A, 2008, 470 , 539

An envelope of radio emission only a little more extended at LOFAR HBA frequencies

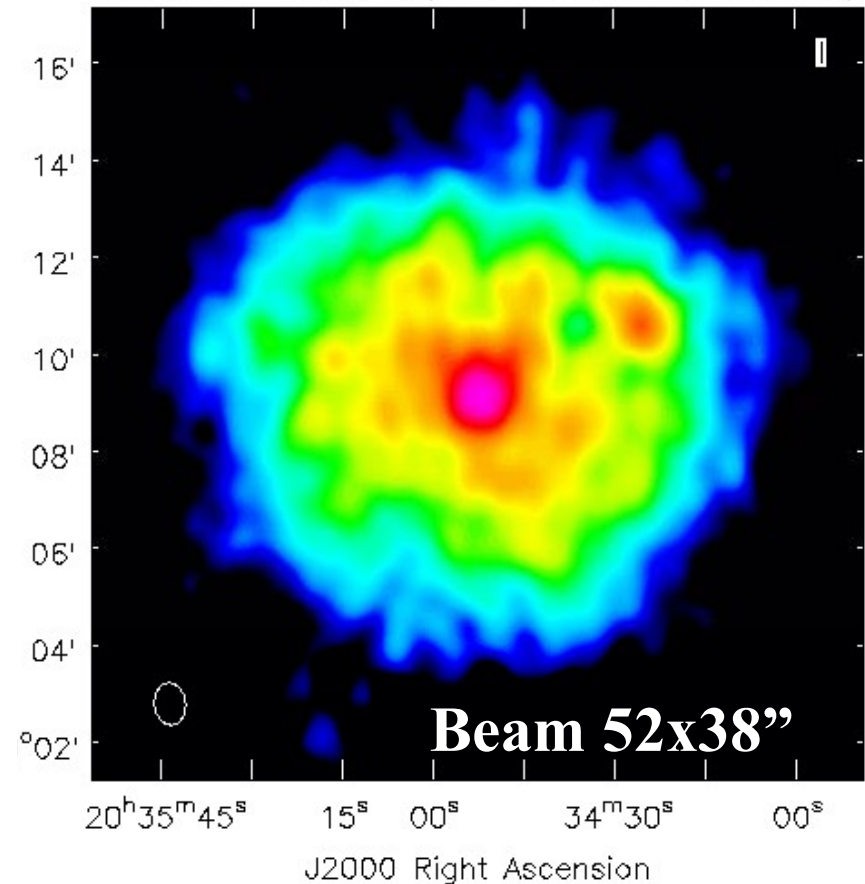
Observations of NGC6946

LOFAR Survey of Nearby Galaxies – LOFAR Cycle 0

NGC6946 – The Westerbork SINGS survey



NGC6946 – Block 0 (122.85 MHz, BW 5.273MHz)

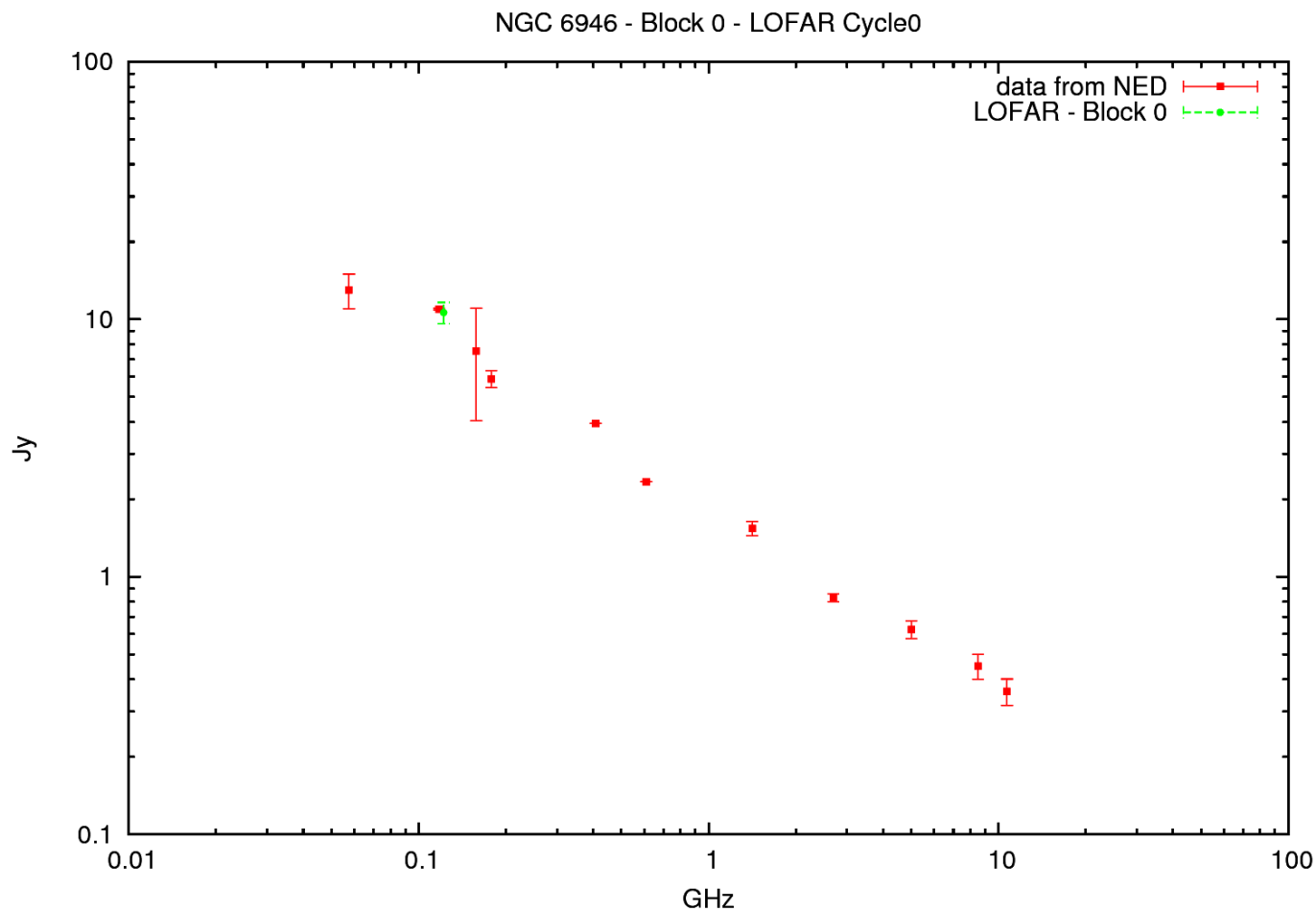


**SINGS map convolved to LOFAR
resolution (52x38arcsec.)**

Observations of NGC6946

LOFAR Survey of Nearby Galaxies – LOFAR Cycle 0

Total radio spectrum of NGC6946 with LOFAR data from Block 0 (green point)

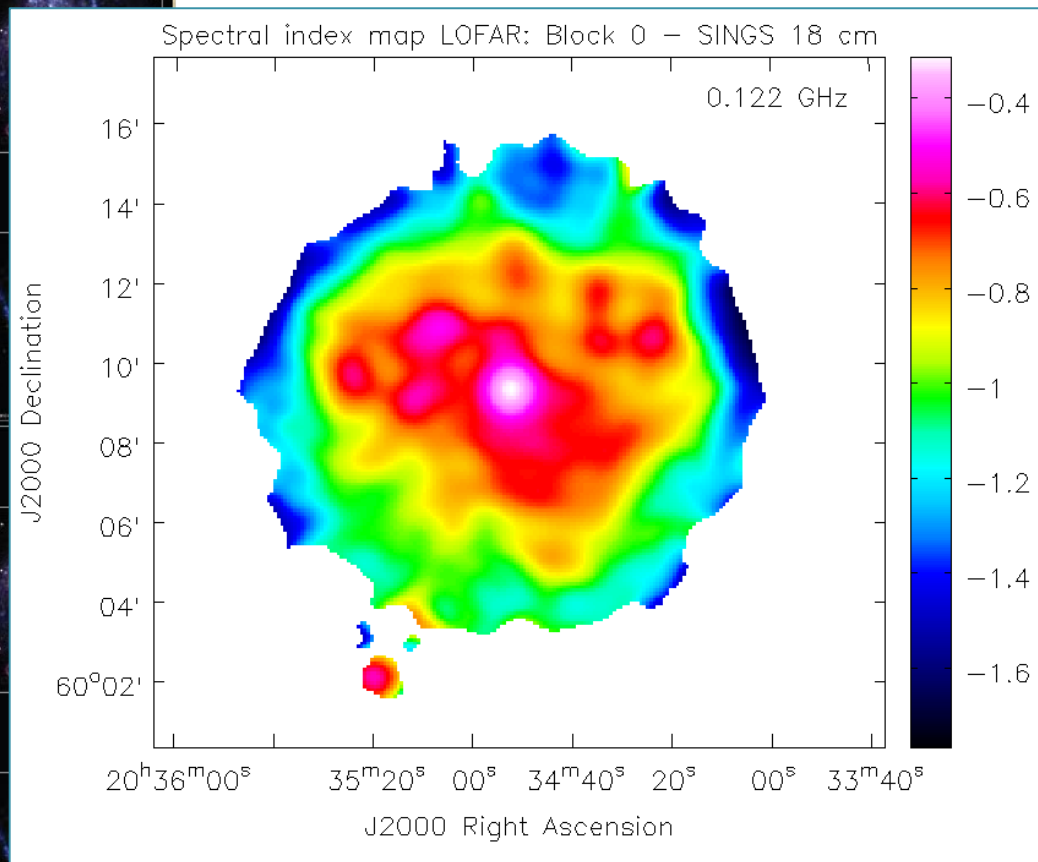


Observations of NGC 6946

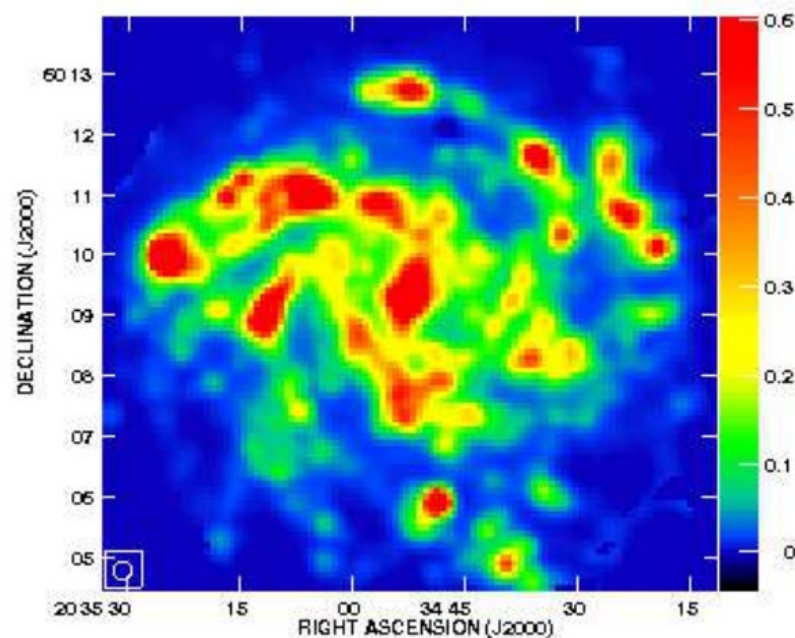
LOFAR Survey of Nearby Galaxies – LOFAR Cycle 0

Spectral index map

- LOFAR data Block 0, SINGS 18 cm, res. 53



**Spectral index flat in
place of giant HII regions**



**Free-free emission at 3.5
cm**

Tak et al. 2012

Observations of NGC6946

LOFAR Survey of Nearby Galaxies – LOFAR Cycle 0

Summary/ Next steps

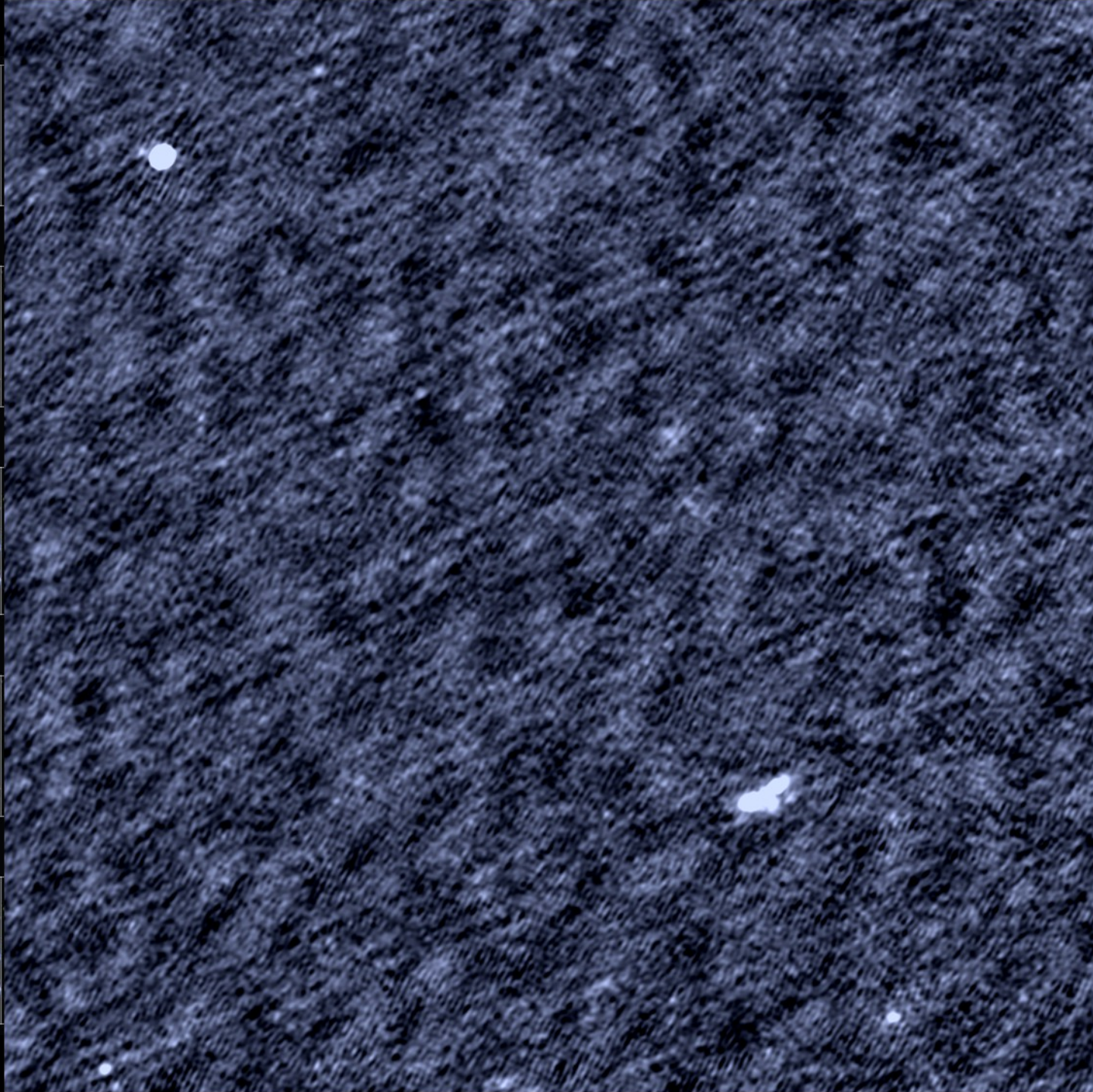
- Presented preliminary results from one Block of data: total power map, total flux of the galaxy and spectral index map are very promising.
- Data processing of next two Blocks are almost done.
- Remaining data Blocks should be processed in few weeks.
- Improving spatial resolution to 20 arcsec. (ν range < 20 K λ).
- News: calibrator data are nearly fully processed, target data are being downloaded

We plan the following studies:

- Processes that shape total spectrum of NGC 6946 and local thermal absorption in galaxy core and H II regions
- Extended radio emission, CRE propagation
- RM Synthesis technique



3C295
10
subb



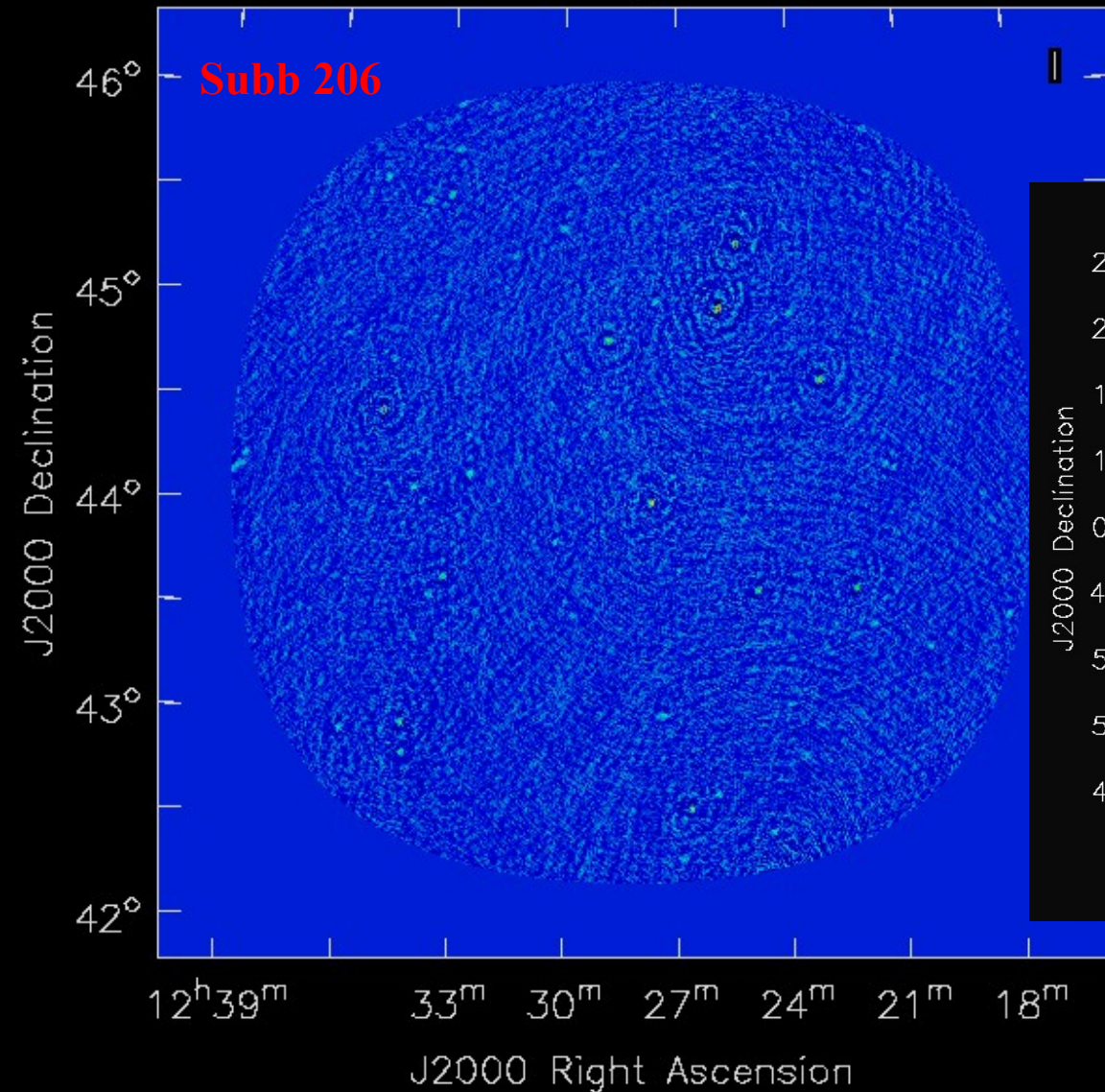
First attempt - transfer of solutions

+ phase calibration with GSM



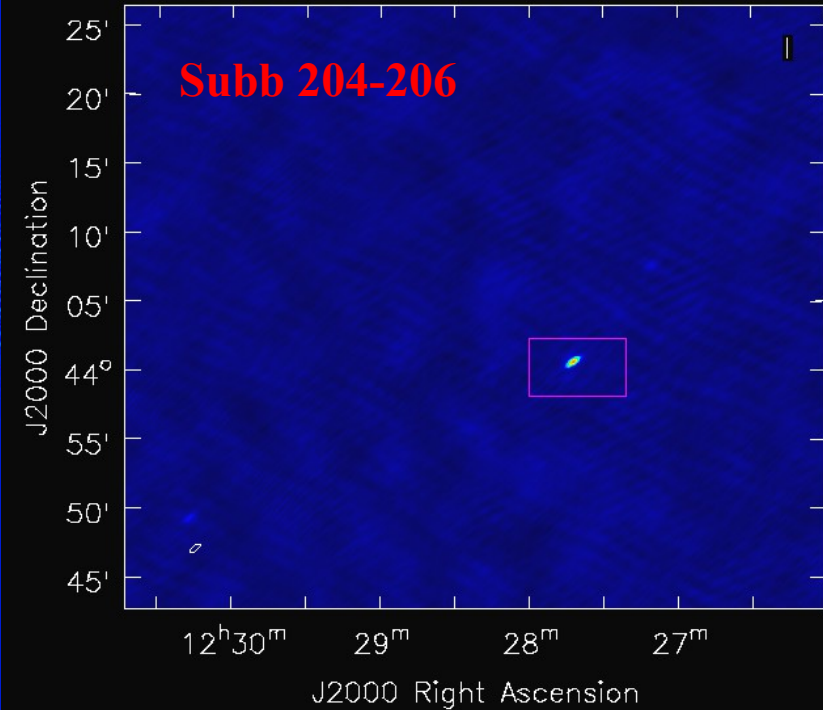
N4449_SB204.img.restored-raster

Subb 206

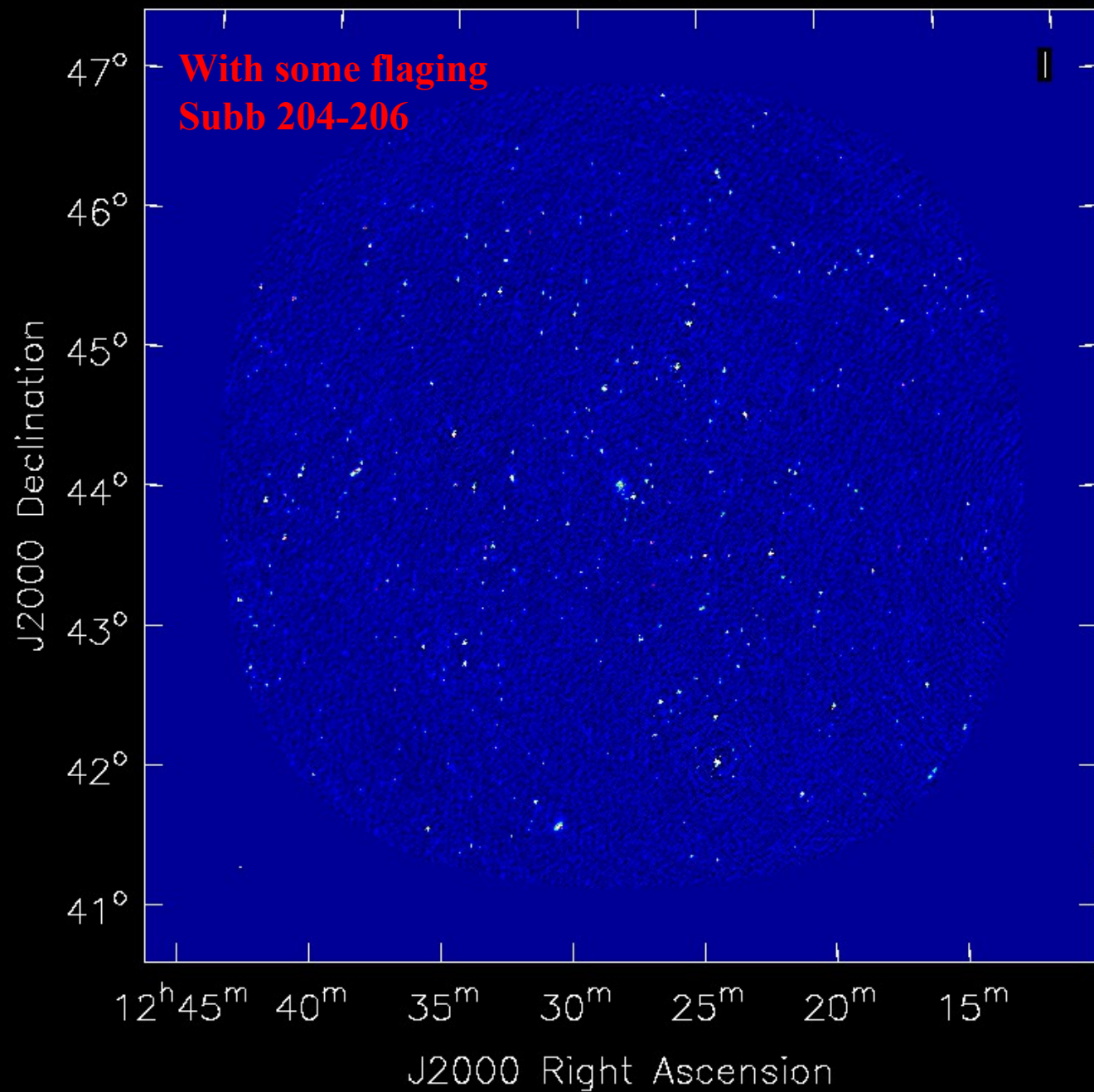


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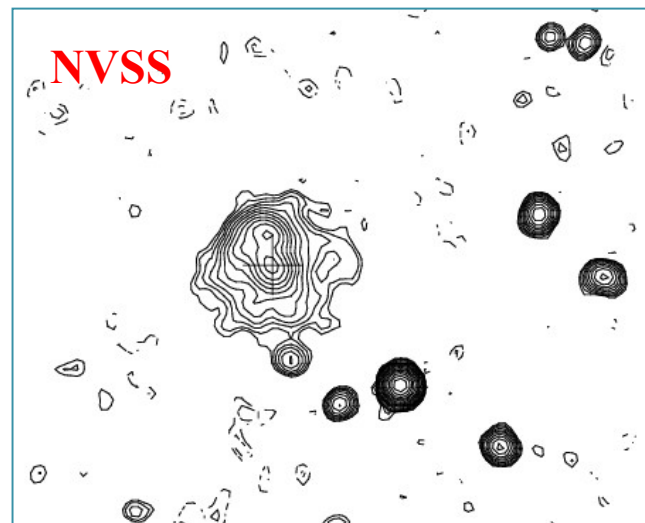
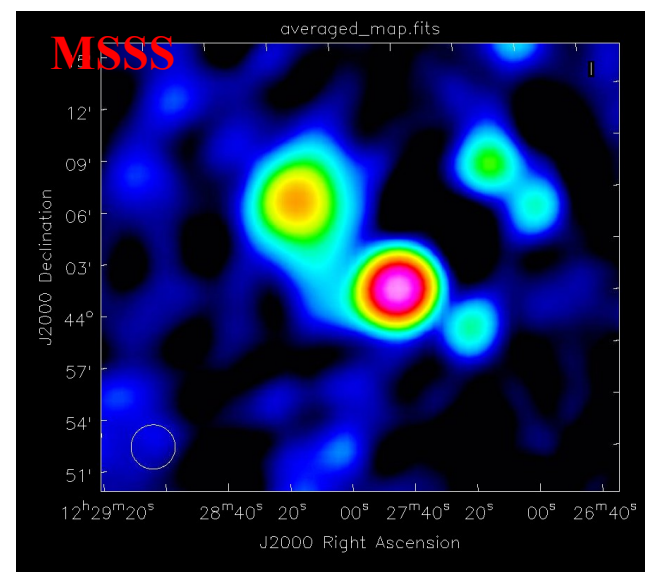
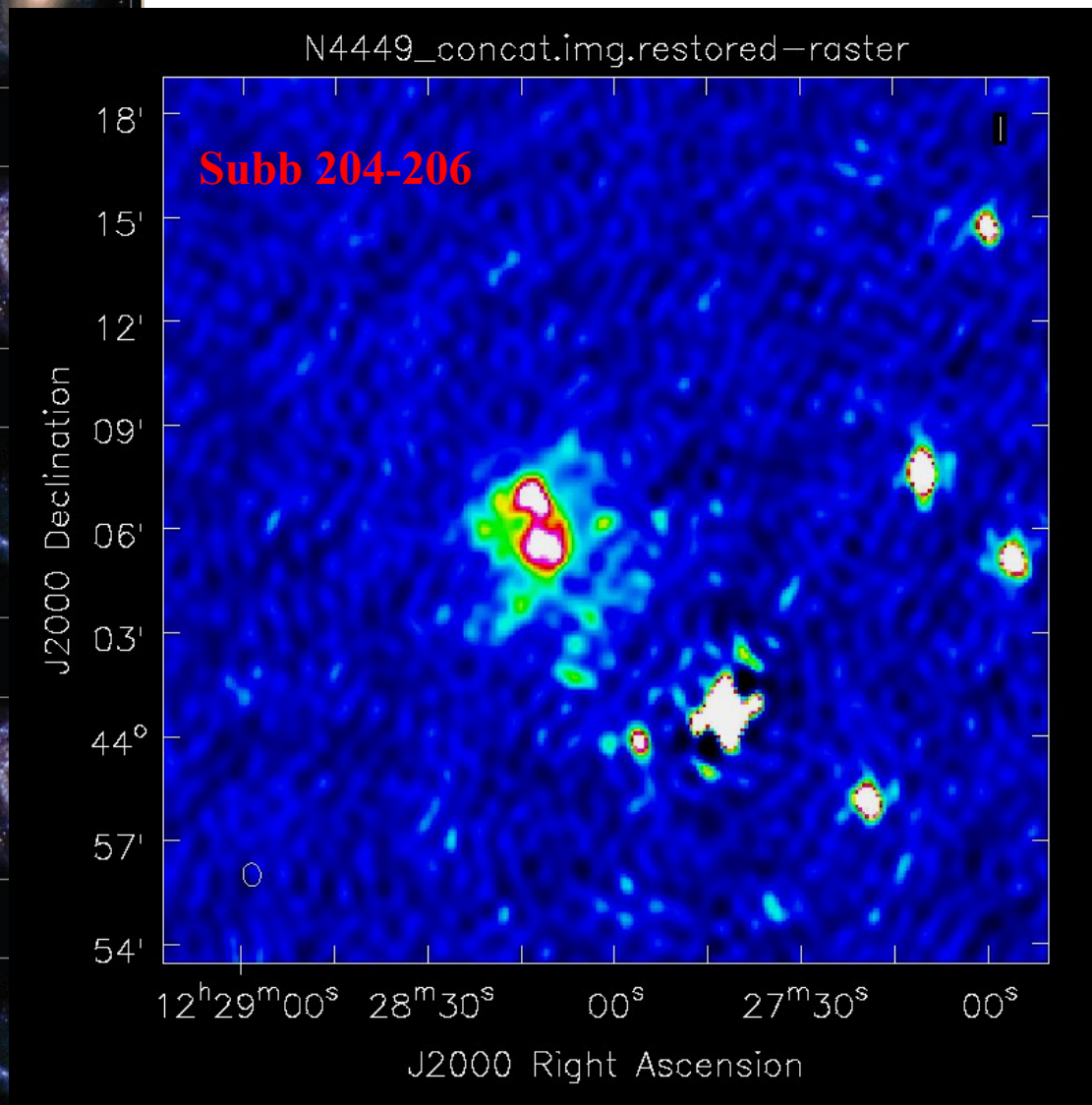
Subb 204-206



N4449_concat.img.restored-raster



1% of the data



Data are now on their way to Krakow – to be reduced on our small cluster/ZEUS



● Statistical studies of galaxies

● Exploitation of MSSS data

Coordinators: Krzysztof T. Chyzy, Rainer Beck, George Heald

Data managers and co-authors: Wojciech Jurusik, David Mulcahy, Blazej Nikiel-Wroczyński, Uli Klein, Katharina Sendlinger, Enno Middelberg, Bjorn Adebahr, Francesco Gasperin, John Conway, Eskil Varenus, David Rafferty, Rosita Paladino, Valentina Vacca, MSSS

Sample selection

- No 60 galaxies sample – biased
- Bigger -> better, statistically complete, can allow studies accross Hubble sequence
- But we are limited by MSSS sensitivity ~15-20mJy
- 1.49GHz Atlas of Spiral Galaxies (Condon, 1987) (314 objects)
- 1.49 GHz atlas of the IRAS bright galaxies (Condon+, 1990) (631)
- **New VLA Sky Survey (NVSS) Cat of IRAS 2 Jy Galaxies (Yun, Reddy, Condon 2001) (1809)**

Not complete. Added: $b < 10$ - IC10
 NGC 628, UGC12914, NGC3646, NGC4217, NGC4449,
 NGC5457
 from Condon 1990, 1987

Criteria:

- $D > 2'$ (avoid LIRGs, another project led by John Conway)
- Cross-matched with RC3, $T > 0$
- Removed obvious AGN dominated galaxies

Sample	Number	limit 1.4 GHz	limit 140 MHz
Large	144	>50 mJy	>250
Medium	80	>100	>500
Small	49	>150	>750

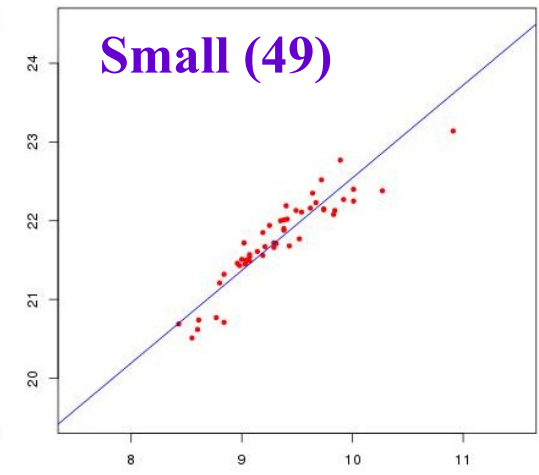
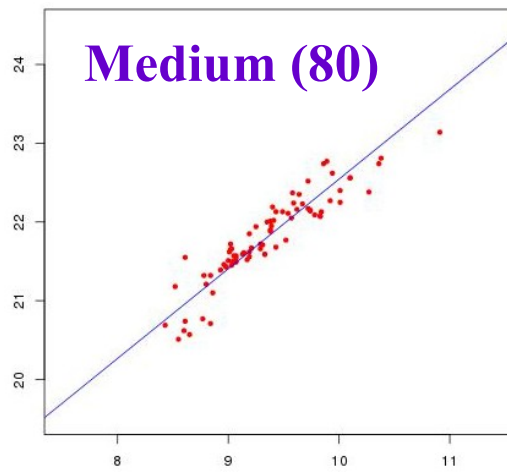
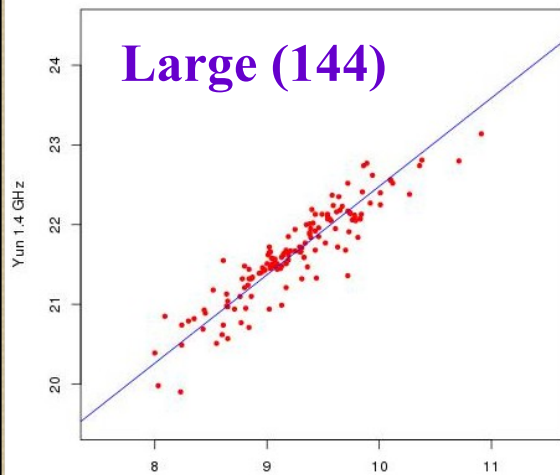
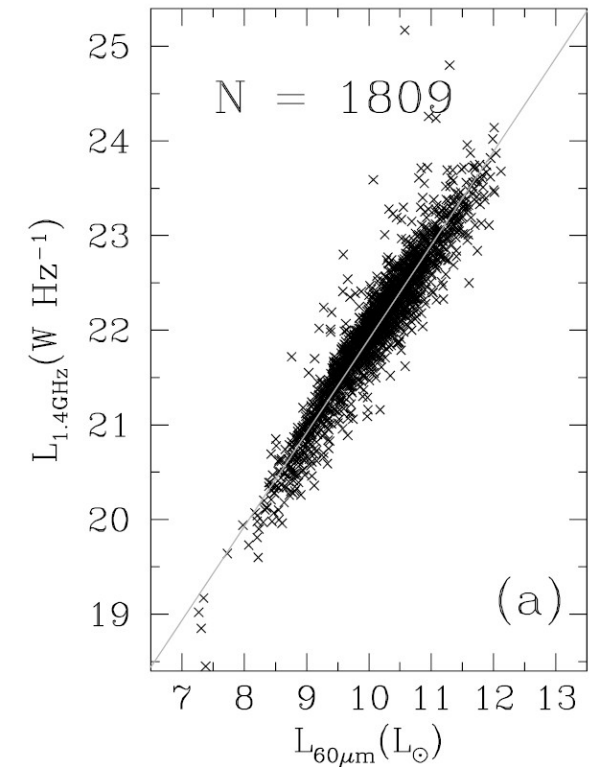
Are the samples scientifically valid?

- Unbiased?
- Small but representative?

Yun et al. sample used for studies of

- RLF
 - Radio – infrared correlation
- Deviation from linear trend for weak sources:

cirrus emission or CR losses by diffusion in low mass galaxies

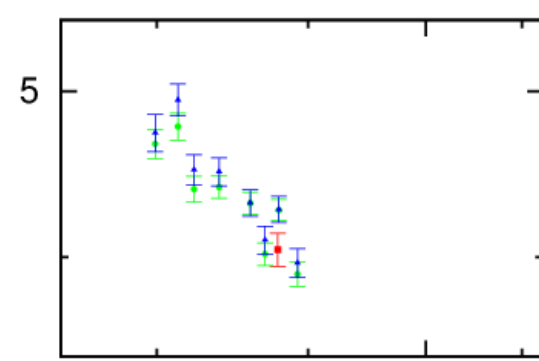


IRAS 60 SLum

IRAS 60 SLum

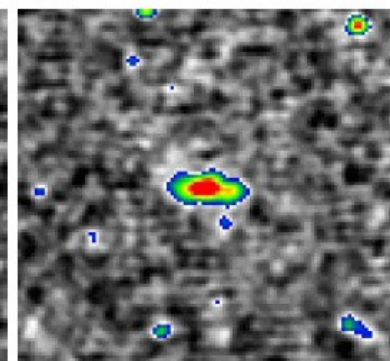
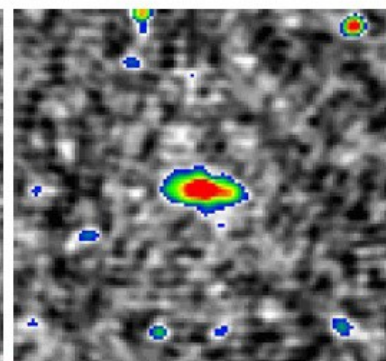
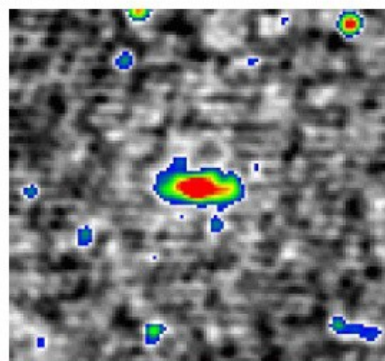
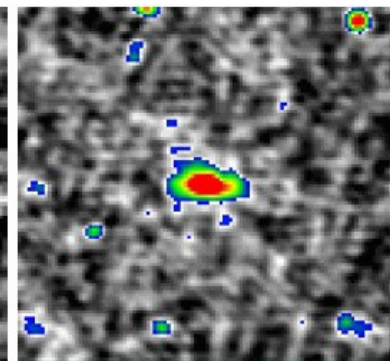
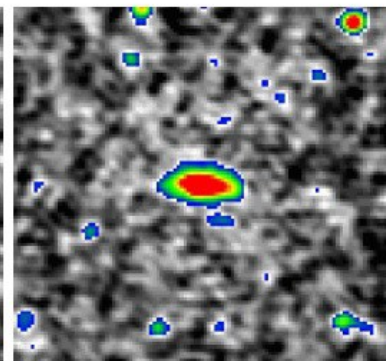
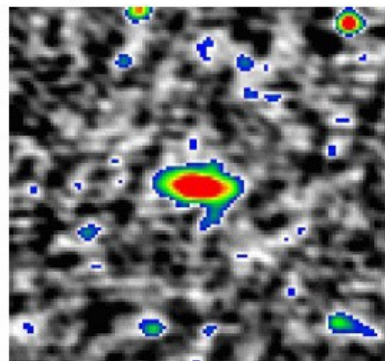
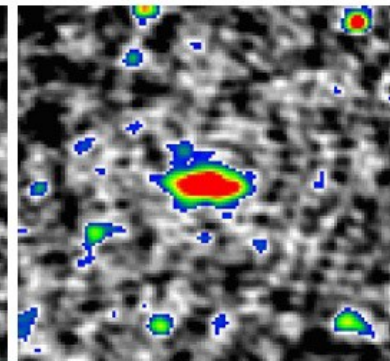
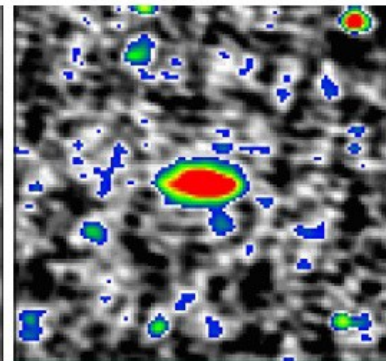
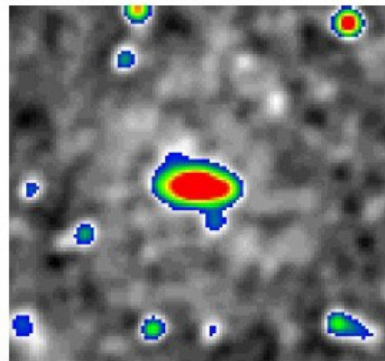
IRAS 60 SLum

Jy



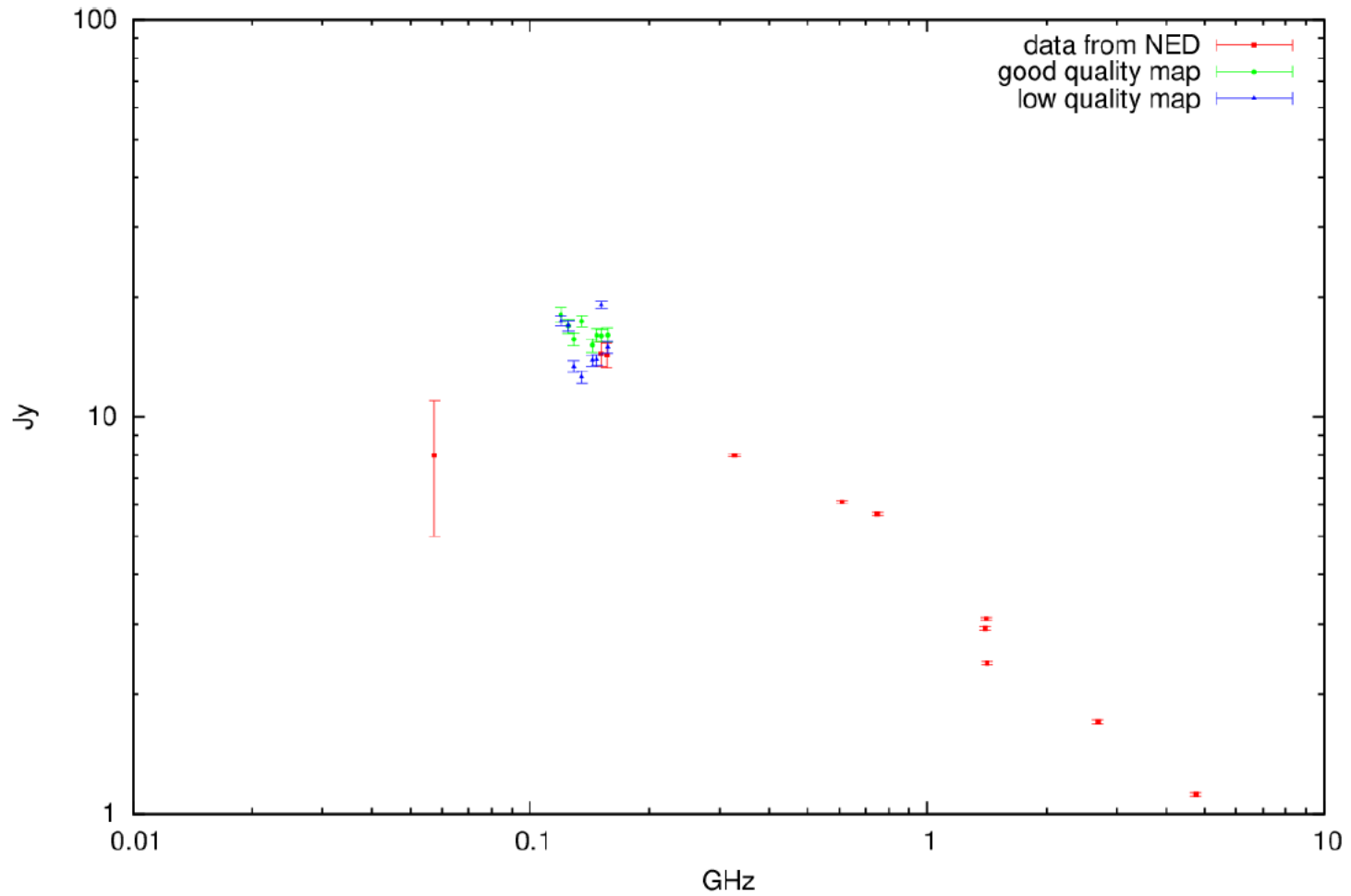
Are MSSH data on galaxies reliable?

NGC4631



Are MSSS data on galaxies reliable?

5. Compare spectra for visually "good" and "bad" quality maps of IC342 (the galaxy was close to the centre of one field and close to the edge in another field respectively).



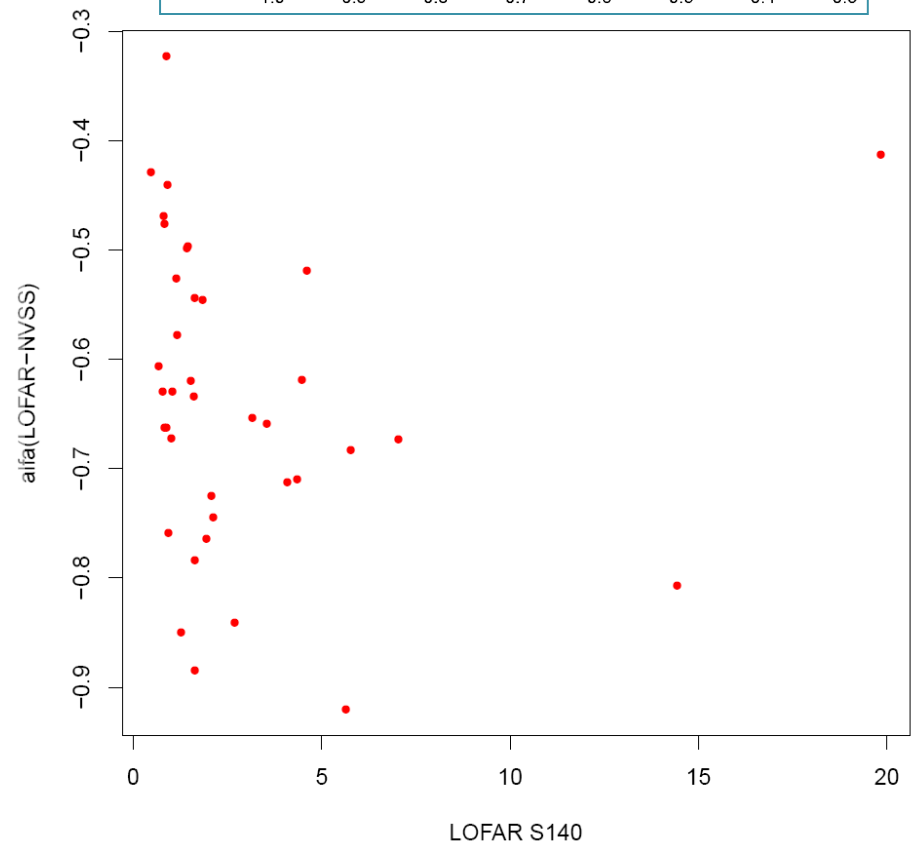
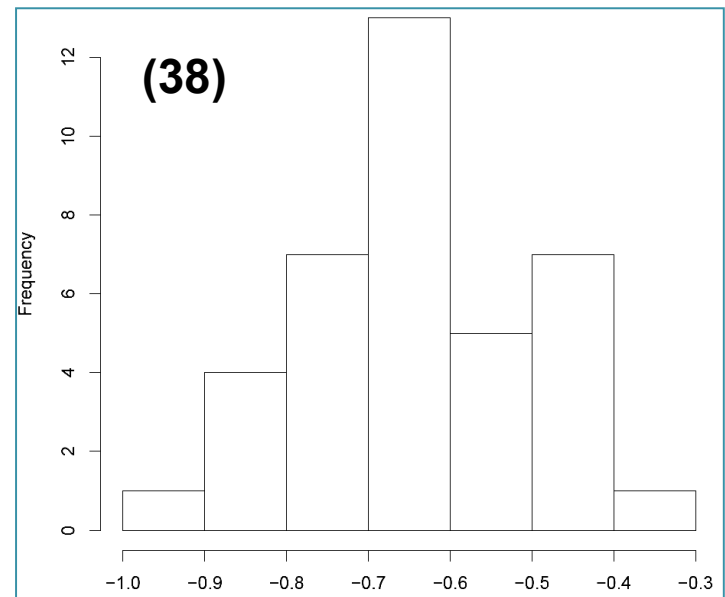
Conclusion: The quality of the map is very important for the spectral trends (better maps show the trend more clearly). The averaged flux from worse maps is similar to good ones.

Spectral index LOFAR-NVSS

- Symmetric distribution
- $\alpha = -0.64 \pm 0.02$

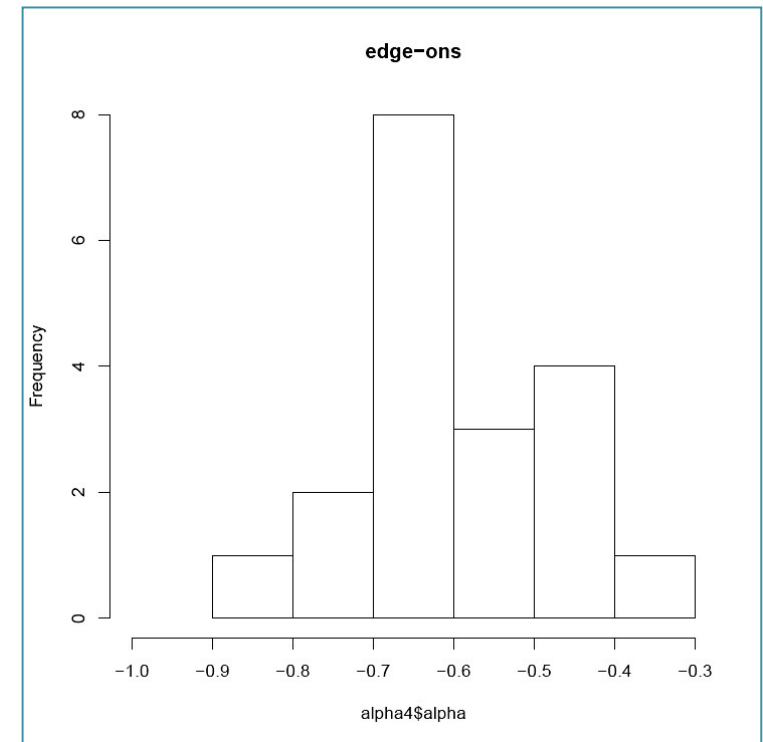
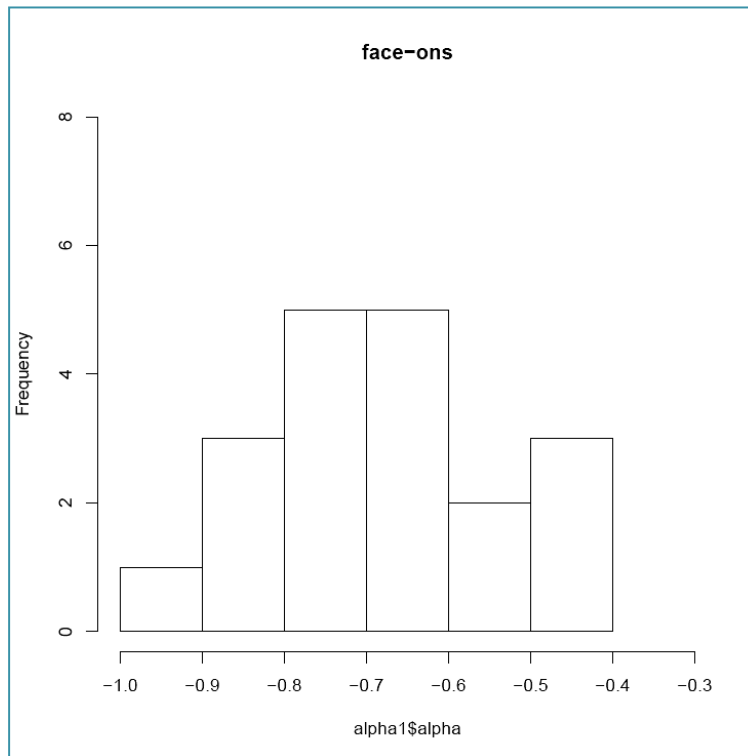
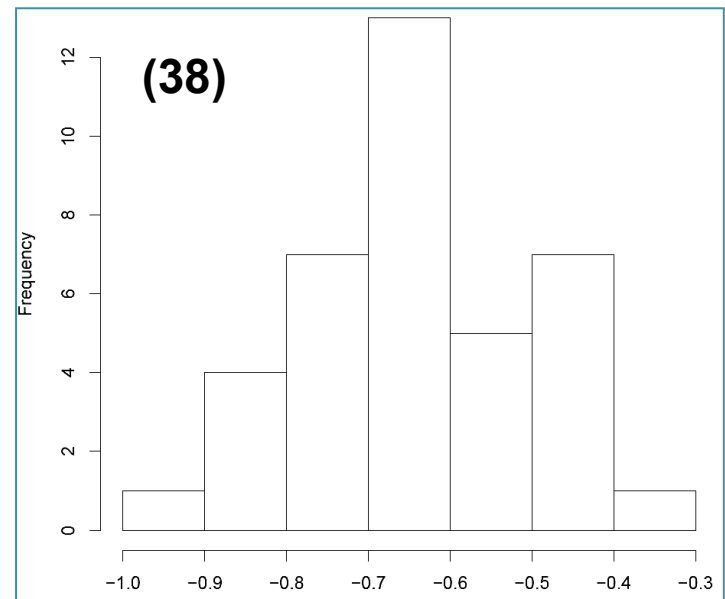
Gioia et al. 1982
 $\alpha = -0.74 \pm 0.02$

- Systematic thermal absorption (or uncertain calibration)
- No strong bias of low α towards low radio flux



Spectral index LOFAR-NVSS

Wilcoxon test rejects at $p\text{-value}=0.04$
the null hypothesis of the same
population of galaxies in favor of the
alternative one of edge-on galaxies
having flatter spectra



LOFAR radio – infrared correlation

- Trend of radio deficiency for weaker sources (diffusion of CRs?)
- Larger spread (errors or thermal absorption?)
- More galaxies needed to confirm trends (medium sample)

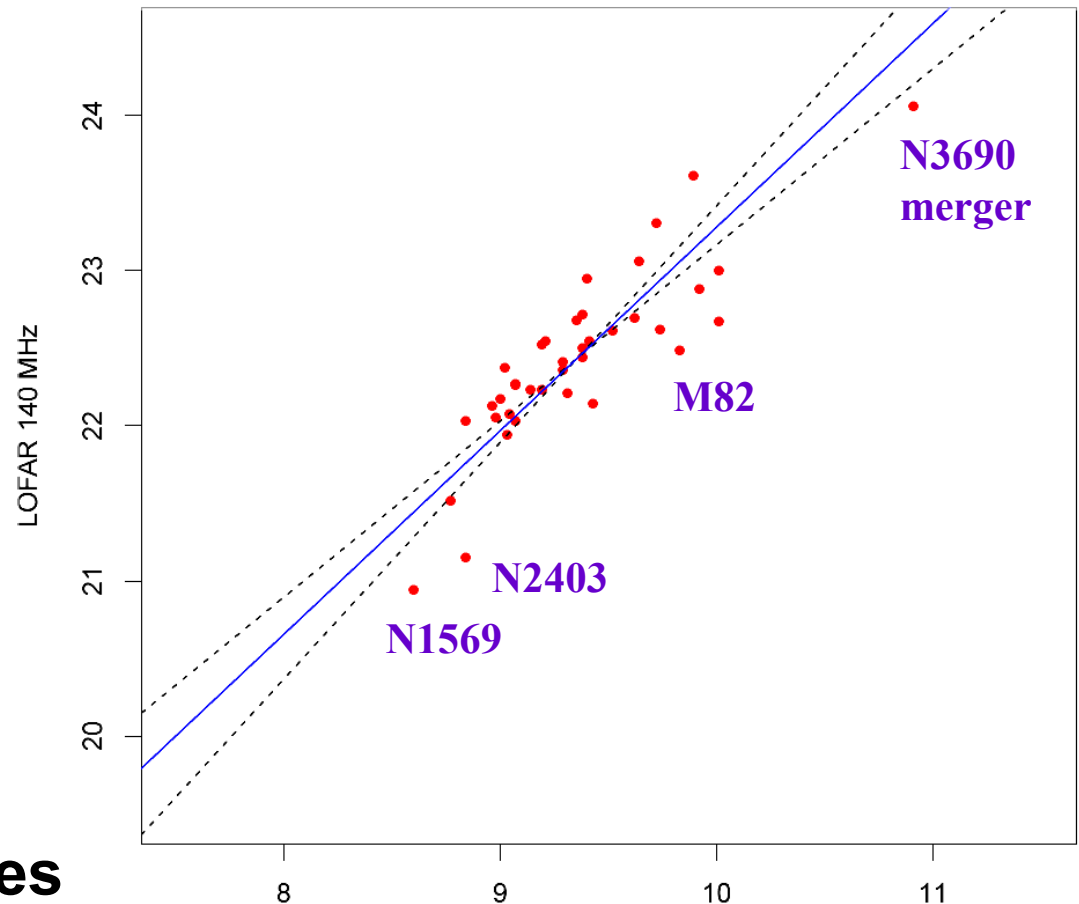


TABLE of slopes

	LOFAR 140 MHz	Yun+ 1.4 GHz
Small	1.31 ± 0.15	1.18 ± 0.09
Medium	n.a.	1.14 ± 0.08
Large	n.a	1.11 ± 0.05

Latest News



- Investigation of the cleaning depth is now being performed – how much flux has not been cleaned yet?
- Building the galaxy spectra: new people joined and they are collecting the literature data to build the SEDs
- Kati released new version of her script, which should make the measurements easier



Summary



- **LOFAR computations now available in Krakow**
- **Stephan's Quintet – shocks visible**
- **NGC6946 – not larger extent, spectral index corresponds with analysis of thermal emission (Herschel)**
- **NGC4449 – preliminary maps from 1% of data shows almost full extent of the galaxy at 1.4 GHz**
- **MSSS – spectral index flat (-0.64), no strong bias from weak sources**
- **MSSS – radio-FIR steeper (thermal absorption?), radio deficient galaxies present**
- **Constantly making progress!**

